

XVIII. *The Ascidian Family Caesiridae*

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The Caesirids [Molgulids], like so many other systematic groups, are in need of a revision which will indicate relationships not only of the genera, but of all the other classificatory divisions. The genus *Molgula*, in particular, has come to include so many species that the identification of a species without any delimitation of sub-genera has become a matter of considerable difficulty. Postponement of attempts to classify the species further only increases the confusion, since the descriptions of new species are practically certain to be in most cases insufficient for subsequent assignment to sub-groups. We desire to contribute toward the classification of this family, considering principally those forms which we have had occasion to study.

Nomenclature

The International Rules of Zoological Nomenclature are the result of a careful attempt by an International Committee of zoologists to put nomenclature on a fundamentally just basis. The Rules have received the approval of the International Congress. There is, consequently, no more generally accepted guide for proper usage in the naming of animals. The outstanding object in the formulation of the rules has been to attain uniformity and stability. We believe that this object will be achieved only by a strict adherence to the rules unless and until they are changed or abrogated in special instances by such general consent as approval by an international congress. For these reasons we do not propose to adopt the arbitrary list of "Ascidiarum nomina conservanda" prepared by Hartmeyer in consultation with Michaelsen and Sluiter.

Parallelism and phylogeny

In the recent past the general aim of systematists has been to produce a genetic classification, that is one, which would correspond with the evolutionary history of the group under consideration. It has been taken as axiomatic that relationship proves community of origin. In the inorganic world we do not hold to this view. It is a commonplace that substances to all intents and purposes identical

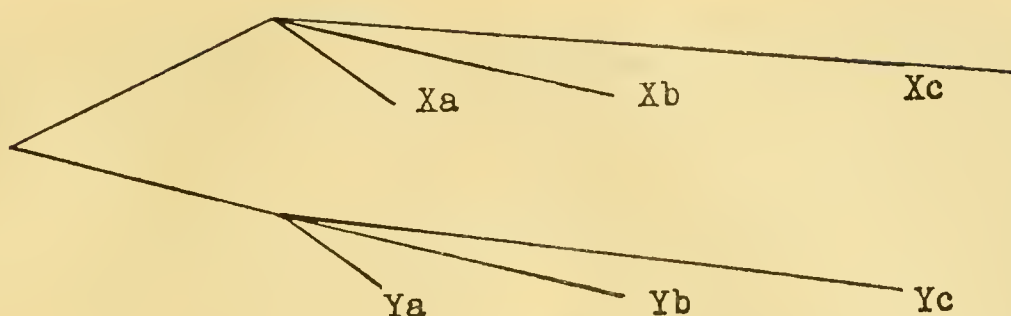
with each other arise quite independently of each other, and widely separated in space and time. Not only so, but these substances which are indistinguishable from each other may originate in widely dissimilar fashion. The same has been shown to hold true for organic substances, as witness the numerous ways in which urea can be synthesized from inorganic sources as well as in living organisms.

Apparently the only good reason for believing that this is not also true of organisms themselves is that they are comparatively so complex and so rare. The more complex a kind of thing is, and the less frequently it occurs, the more reasonable it is to suppose that the conditions necessary to produce it have obtained only once, and that consequently all of that kind are connected in origin.

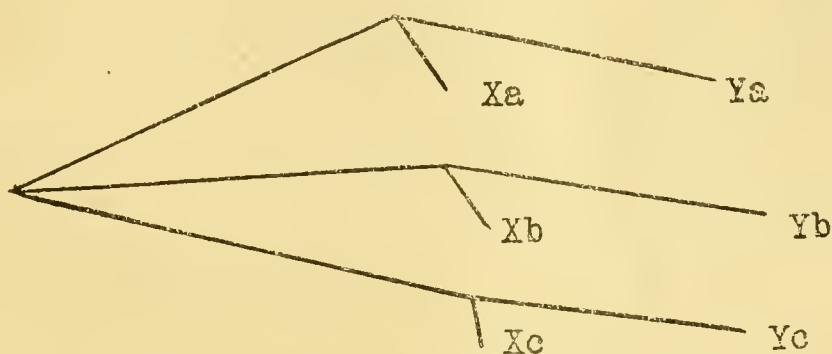
Are we altogether justified in making this supposition? As to the actual origin of entirely new forms we have not yet the necessary knowledge to state that a certain new form has arisen repeatedly at different times and places. In the origin of new forms by the crossing of common species, we are able to affirm that the same kind has been produced on many occasions, and the study of genetics has shown us how these new kinds can be produced at will.

In systematic study there has arisen a large body of facts that supports strongly the view that the same species has arisen repeatedly and even by different paths. When almost identically the same form occurs at places remote from each other, those who are committed to the view that a species has been produced but once, predicate as a matter of course some transference of the species from one place to the other, and in this they are justified, for the spreading of a species is a phenomenon readily demonstrable, and frequently observed, whereas the production of a new species has so far been a doubtful thing.

However, the phenomena of parallelism afford cases that admit of no other interpretation than that frequently the same evolutionary process has been repeated. Examples of intergeneric parallelism are not infrequent among Ascidians as well as in other groups of animals, and a hypothetical case may be used as an illustration. In two closely allied genera, X and Y, there are parallel series of species, Xa, Xb and Xc, and Ya, Yb and Yc, where Xa and Ya are similar except in generic characters, and the same for the other pairs Xb and Yb, Xc and Yc. If the classification correctly interprets the phylogeny or origin of these forms, the following arrangement would approximate their ancestral history.



Cope (1868, p. 272) was led to consider it possible that "one and the same species (if origin be the definition), has, in the natural succession, existed in more than one genus." With such a conception the classification would not be expected to show the natural succession, which might in the above case be as follows.



In each of these arrangements parallel evolution is well shown. In the former case there is the independent production of the corresponding a, b and c species in the two genera, and in the latter case the independent production of the X and Y generic characters in the a, b and c lines of evolution. It is quite conceivable that both methods of evolution have been followed, and that the species Yb has been produced in two different ways, namely, by acquiring the generic characters (Y) first and the specific characters (b) later, as in the first scheme shown above; and by acquiring the specific characters (b) first and the generic characters (Y) later, as in the second scheme. The Mendelian phenomena of genetic segregation indicate that, if this did occur, the final products in the two cases might be indistinguishable.

As the facts of parallelism prove that nearly related groups of species have passed through almost identical evolutionary processes in many instances, it is only reasonable to suppose that groups of individuals all belonging to the same species still more frequently

evolve along the same paths. If this evolution be of the nature of the production of two or more kinds from one, for example a_1 producing b_1 and c_1 , and a_2 producing b_2 and c_2 , we have as a result that the dissimilar forms b_1 and c_1 , or b_2 and c_2 are more closely related than are the similar forms b_1 and b_2 , or c_1 and c_2 . Also there is the possibility of the same form being produced in two different ways as indicated above for Yb. From these considerations it seems very doubtful whether our ultimate aim in classification should be a phylogenetic arrangement, or not.

The Unit in Classification

The unit which we use in classification is the species, a thing that admittedly is not capable of very exact definition. In describing a species we consider those characters to be irrelevant that can be shown to have resulted from unusual conditions during the development of the individual, that is, we definitely exclude differences that are purely environmental. In our description of a species we feel free to include not only the characters of the adult, but also those of any or all stages from one generation to the next. It is evident from what we exclude and from what we include that we are attempting to describe the heritable part of a more or less homogeneous group of individuals. The only part that is heritable, that is, that is transmitted from one generation to the next, is the germ plasm, and consequently that it is that we are attempting to classify. We deduce the nature or structure of this apparently simple, but really complex thing, the germ plasm, from what it produces under certain standard or natural conditions, namely from the characters of the adult and of the various developmental stages leading to the adult. We are forced to use these very indirect means of determining the properties or nature of the germ-plasm, for we have not yet been able to determine its distinctive properties directly.

Our position in regard to organic species is similar to, but not so good as, that in regard to chemical elements. We know the properties of the chemical elements not only indirectly from what they produce under definite conditions, namely, from their compounds, but also directly from the characteristic properties of the elements themselves and to such a degree that a theory of their structure is being worked out. For both species and elements we deduce theoretical evolutionary series from a simple to a complex condition, without yet having been able either to observe in nature or to produce experimentally a single transformation in the series.

At the present time we classify germ plasms on the basis of their properties determined indirectly. We may look forward to having at some time in the future a knowledge of their structure as a basis for classification. Such knowledge will be the outcome of analysis or synthesis of the germ plasms. While there is no immediate prospect of our being able to analyse and synthesize these in the direct chemical fashion, there is already well under way an indirect analysis and synthesis of germ plasms, namely, in the elucidation of the Mendelian phenomena. When work in this comparatively new field shall have become sufficiently extensive it will provide the foundation for a much better system of classification.

Early History of the Family

Baster (1760) appears to have been the first author to describe a member of this family, and, believing his animal, which was found on the coast of Holland, to be new, he gave it the name *Ascidium*. This was adopted by Linnaeus in the 12th edition of his *Systema Naturae*, under the altered spelling *Ascidia*, as the name for all the sea-squirts which he knew. Later, when the group of sea-squirts was subdivided, the name with variable spelling came into general use for the whole group, as (in English) *Ascidians*.

Baster's species has not been recognized since his time. It was probably the same form as described in 1846 by P. J. van Beneden under the name *Ascidia ampulloides*. If this can be determined there seems no good reason why Baster's name *Ascidium* should not come into use for the group of species that includes *A. ampulloides*.

Pallas in 1776 and 1787 described an *Ascidia globularis* from the Kara sea. We have shown that this belongs to the genus *Rhizomolgula*, instituted by Ritter in 1901 for specimens from Alaska, and it now appears that there is just the one species of this genus, which was not rediscovered until more than a century had elapsed. In the last twenty years its distribution has been quite well worked out.

In 1816 Savigny described from the Red Sea a species of Ascidian which he named *Dione*, which he placed in a new genus *Cynthia*, and for which he made a special tribe, the *Cynthiae Coesirae*. In 1822 Fleming erected this tribe into a genus, using the name *Caesira* and indicating Savigny's species as the type. Until Baster's form is cleared up, the genus *Caesira* is to be considered the oldest in the family, and hence gives its name to the latter.

In 1825 MacLeay described the new genus and species *Cystingia griffithsii* from material obtained in the Canadian arctic. This has

been of doubtful systematic position until recently, when we (Huntsman, 1922) showed it to be identical with the *Clavelina chrystallina* of Möller (1842), which was obtained at Greenland. *Cystingia* is, therefore, the second named genus in this family.

In 1834 Quoy et Gaimard described the species *Ascidia tumulus*, obtained at Australia. It was described in detail by Pizon in 1898. Hartmeyer (1914, p. 3) has called attention to the fact that Gervais in 1840 instituted the genus *Syphonotethis* for this species.

In 1848 Forbes formed the genus *Molgula* for the species *M. oculata* and *M. tubulosa*. This genus was the first genus of the family to be generally adopted and recognized by systematists, and, when the family was separated by Lacaze-Duthiers in 1877, it was considered the oldest genus, and the family was accordingly called the *Molgulidae*, by which name it has gone until quite recently.

Since the middle of the last century there has been a steadily increasing number of species and genera added to this family.

The Classification

The current classification of this family is particularly unsatisfactory as it lacks any sub-division of the heterogeneous genus *Caesira* or *Molgula*. The history of the family has largely been a continued separation of small genera from the old, comprehensive genus *Molgula*. Many of the new groups proposed have not met with general acceptance, so that *Molgula* has become to an increasing extent an unsatisfactory assemblage of diverse species.

Giard in 1872 proposed the genera *Gymnocystis* and *Lithonephrya*, neither of which have been recently recognized. In founding the family in 1877 Lacaze-Duthiers instituted the genera *Anurella* and *Clenicella*, of which the latter alone has gained any currency. Pizon in 1898 and 1899 introduced the genera *Gamaster*, *Astropera*, *Stomatropa*, and *Meristocarpus*, of which only the first has been accepted. In more recent times we have Seeliger's (1907) *Molgulidium* and *Eugyrioides*, and Hartmeyer's (1914) *Pareugyrioides* and *Molgulina*. Of these four the second and third appear sufficiently well characterized to be valid. No matter what classification proves best there is at our disposal a considerable number of generic names for use in accordance with the International Rules of Nomenclature. In the classification that we propose, these will be used wherever available, but with frequent alteration of diagnosis and scope.

The importance of any group of characters for classificatory purposes varies in inverse ratio with their variability and the extent

of their intergrading. Nevertheless, it cannot be expected that a character distinguishing a classificatory division, no matter how high the grade of the latter may be, shall be absolutely constant and invariable in that division, and shall absolutely fail to intergrade with the opposed character distinguishing a neighbouring division. A division into groups should not be condemned merely on account of intergrading in the characters used in making the division, although it is much better if clearly cut distinctions between natural groups can be shown. The important thing is to define groups that are natural. We may objectively define a natural group as one containing units of a lower grade which can be shown to be similar on the basis of as many and as invariable characters as possible. It is important, therefore, to consider as many characters or systems as possible in an attempt to produce a natural classification.

The principal characters that have been used for distinguishing genera in this family are the following: presence or absence of definite pharyngeal folds, number of folds, arrangement of stigmata, condition of siphonal lobes, position of intestinal canal, number and distribution of gonads. The only features to which sufficient attention seems not to have been paid, and which we wish to emphasize, are the structure, orientation and situation of the gonads. In structure, the chief differences consist in the extent to which the testicular portion is separated from the ovarian part in each gonad, and in the arrangement of the testicular lobes in relation to the ovary. At one extreme, the testicular lobes are closely massed around the ovary, and almost enclose the latter, leaving only parts of the inner and outer surfaces free, and the efferent ducts unite into a common vas deferens, which is closely applied to the oviduct, the two opening together. At the other extreme, the testicular lobes are more or less distinct from the ovary, and are divided into groups, each with its own vas deferens opening separately into the atrial cavity. In orientation, we have in one small group of species, the gonad reversed from the usual condition and opening at its anterior end instead of its posterior. The situation of the gonad varies considerably on the left side and in relation to the intestinal loop, being either in the latter or above it. In the latter case it may be more or less enclosed by a secondary bending of the intestinal loop around it, or it may be above such secondary bending. A new and clearer order is apparent if we take into account these gonadic characters, and we, therefore, propose to make them the basis of the main divisions in the family, indicating at the same time how they are reinforced by other characters.

No matter what basis we use for classification in this family we are confronted with a considerable amount of parallelism. Neighbouring sub-families or genera show similar series of genera or species respectively. This makes classification doubly hard, as it permits of alternative very diverse and, at first glance, equally natural schemes. In the past the characters presented by the pharynx have been considered as of major importance in Ascidian classification. This is owing to the diversity of structure exhibited by this organ as well as to the ease with which this structure may be observed. We believe, nevertheless, that in the classification of this family the characters presented by the pharynx are of minor importance to those presented by the gonads. The fact that the pharyngeal characters used for distinguishing the genera are to a considerable extent such as alter from one type to another during the development of the individual makes them on the whole more variable than the gonadic characters. The latter, also, seem to be more fundamental, that is, related to the structure of the germ-plasm. The reason for this may be that the distinctness of such systematic groups as we are here dealing with depends upon the inability of the eggs and sperms of any two groups to unite, that is, crossing of species or genera whose eggs and sperms are mixed promiscuously in the sea water may depend upon certain peculiarities in the structure of these eggs and sperms. If differences in the structure of the gonads exist, these may well be correlated with differences in the structure of the eggs and sperms that are produced in these gonads.

Seeing that so little attention has in the past been given to the structure of the gonads in connection with classification, it is not surprising that most of the species in this family have not been described fully enough as regards the gonads for one to be altogether certain, or even in many cases to have any idea of, their position in the present scheme of classification, and comparatively few species have been available to us for examination. Many species, and even several genera, have consequently not been brought into the scheme. Further knowledge concerning these is much to be desired, and will make it possible to fill the gaps and correct the mistakes in this classification. In a number of cases, where there has not been sufficient information, a genus or species has been assigned a position on the basis of its structure so far as known.

Synopsis of Genera

A₁. Left ovary in or across intestinal loop, with usually several distinct testicular systems grouped along it. Vasa deferentia not

passing along inner surface and lengthwise of ovary. (*Eugyrinae*).

B₁. A gonad on each side of body.

C₁. Pharynx with nine folds on each side. *Halomolgula*.

C₂. Pharynx with seven folds on each side. *Molguloides*, gen. nov.

C₃. Pharynx with five folds on each side. *Ectorchis*, gen. nov.

C₄. Pharynx with from 5-7 long. bars on each side instead of folds. *Eugyrioides*.

B₂. A gonad on the left side only.

D₁. Pharynx with six folds on each side. *Rhizomolgula*.

D₂. Pharynx with from 6 to 9 long. bars on each side instead of folds. *Eugyra*.

A₂. Left ovary above intestinal loop. Testicular lobes either arranged alongside the more or less elongated ovary, or else somewhat definitely separated from it and in masses. (*Cystingiinae*).

E₁. Testicular lobes arranged along and to a considerable extent on the outer side of ovary. Vasa deferentia attached to mantle (body-wall), running parallel to oviduct, and opening near latter. (Pharynx with seven longitudinal bars on each side in place of folds). *Paramolgula*.

E₂. Testicular lobes bordering and more or less enclosing ovary. Vas deferens single and running along middle of inner surface of ovary to open near oviduct.

F₁. Pharynx with seven folds on each side. *Anurella*.

F₂. Pharynx with six folds on each side. *Euritteria*, gen. nov.

E₃. Testicular lobes bordering and more or less enclosing ovary. Vasa deferentia opening on inner surface of gonad and not running parallel to ovary.

G₁. A single gonad, situated on the left side. *Eugyriopsis*.

G₂. A gonad on each side of the body.

H₁. Pharynx with seven folds on each side. *Molgula*.

H₂. Pharynx with six folds on each side. *Gymnocystis*.

E₄. Testicular lobes more or less separated from ovary and in distinct masses. Vasa deferentia short and not related to ovary.

I₁. Pharynx with from five to seven folds on each side. *Cystingia*.

I₂. Pharynx with seven longitudinal bars on each side in place of folds. *Pareugyrioides*.

A₃. Left ovary (if present), above intestinal loop. Testicular lobes massed at blind end of ovary and radially arranged. (*Caesirinae*).

- J₁. A gonad on each side of body.
 - K₁. A single vas deferens, passing along inner side of ovary and opening near oviduct. *Syphonotethis*.
 - K₂. Vas deferens or vasa deferentia opening into atrial cavity near blind end of ovary, that is, not accompanying the latter.
 - L₁. Pharynx with folds.
 - M₁. Oviduct directed toward atrial aperture. *Caesira*.
 - M₂. Oviduct directed anteriorly, that is, away from atrial aperture. *Lithonephrya*.
 - L₂. Pharynx without folds.
 - N₁. Stigmata present. *Oligotrema*.
 - N₂. Stigmata absent. *Hexacrobylus*.
- J₂. A single gonad, situated on the right side. *Gamaster*.

In order not to burden the present article unduly we have neither indicated the synonymy of the various species, nor given references to the original descriptions, except in a few cases. Practically all the references not given can be found in Hartmeyer's account of the family in Bronn's Tierreich, Bd. III, Suppl. pp., 1316-1329, to which the reader is referred.

Species which we have personally been able to examine for this study are indicated with an asterisk (*).

EUGYRINAE sub-fam. nov.

This sub-family shows a very general tendency for the stigmata that form the infundibula not to become sub-divided as development proceeds. This is well shown in the genus *Eugyra* and is responsible for the name. In *Rhizomolgula*, *Ectorchis*, and *Molguloides* more or less subdivision occurs. In *Halomolgula*, which is doubtfully assigned to this group, subdivision has been carried to an extreme.

In two of the genera (*Eugyra* and *Eugyrioides*), representing different sub-groups, the pharyngeal folds fail to develop into the condition characteristic of the family, the post-larval condition of a single longitudinal bar for each row of stigmatic coils remaining throughout life.

The dorsal tubercle remains for the most part very simple, in many cases not showing more than a simple funnel-shaped aperture. Where the aperture becomes slit-like and bent it takes the form of a simple horse-shoe with the opening between the horns usually directed anteriorly or to the left.

The chief character of the sub-family is the position of the left gonad, which is in or placed across the primary intestinal loop. In addition there are usually several testicular systems for each gonad, and the vasa deferentia are for the most short and open separately into the atrial cavity, not passing along the inner surface of the ovary to open near the oviduct.

HALOMOLGULA Ritter

Pharynx with nine well-developed folds on each side. Infundibula extending into folds, each having numerous short stigmata. Dorsal lamina with crenulated margin. Dorsal tubercle a simple opening.

A gonad on each side, the left in the intestinal loop. Testicular lobes bordering the ovary. Number and course of vasa deferentia not known.

Type and single species.—*H. ovoidia* Ritter.

Ritter established this genus largely because of there being calcareous spicules in processes of the test. The position of this genus in our system is somewhat doubtful, but it would seem to belong near *Molguloides*.

MOLGULOIDES gen. nov.

Syn. *Molgula* et *Caesira* auct. (partim).

(*Molgula* and εἶδος, appearance).

Pharynx with seven folds on each side. Infundibula extending into folds, each having a number of rather short stigmata. Dorsal lamina with smooth margin. Dorsal tubercle simple, or horse-shoe shaped with opening between horns directed to left.

A gonad on each side, the left in the intestinal loop. Testicular lobes bordering and more or less enclosing ovary. Several vasa deferentia, not accompanying oviduct.

Type species—*M. vitrea* (Sluiter) as described by Van Name, 1918, p. 68.

Molgula sordida Sluiter, *M. vannamei* Oka (1914, p. 452) and *M. japonica* Hartmeyer probably belong here, but they are as yet insufficiently described.

ECTORCHIS gen. nov.

Syn. *Molgula* et *Caesira* auct. (partim).

(ἐκτός and ὄρχις, in allusion to the external position of the male part of the gonad)

Pharynx with 5 folds on each side. Infundibula extending into folds, each having many stigmata spirally arranged. Dorsal lamina with smooth margin. Dorsal tubercle with aperture horseshoe shaped, the horns inrolled, and the opening between directed forwards.

A gonad on each side, the left placed across the intestinal loop on its inner side. Testicular lobes in a large flat mass against mantle and (on left side) intestinal loop, and outside blind end of ovary. Vas deferens attached to mantle and passing along and beyond open or atrial end of ovary.

Type and single species—*E. hupferi* (Michaelsen).

The systematic position of this form is doubtful. In the relations of the testis and vas deferens (on the outer side of the ovary) it resembles *Paramolgula*. The relation of the gonad to the intestine is similar to that in some species of *Eugyra*, and the stalk with special muscles resembles the "root" of *Rhizomolgula*.

EUGYRIOIDES Seeliger

Pharynx with from 5 to 7 longitudinal bars on each side in place of folds. Infundibula in rows corresponding to the bars, each consisting of two long spirally coiled stigmata. Dorsal lamina with smooth margin. Dorsal tubercle a simple opening.

A gonad on each side, the left in the intestinal loop. Testicular lobes bordering and more or less enclosing ovary. Several vasa deferentia not accompanying oviduct.

Type species—**E. glutinans* (Möller). Another species is *E. schmidtii* Redikorzew (1914, p. 42). *E. guttula* (Michaelsen), *E. molguloides* (Sluiter), and *E. symetrica* (Drasche) have been assigned to this genus, but the structure of the gonads is not sufficiently known for their systematic position to be determined. *Paramolgula arctica* Bonnevie has also been placed in this genus, but the author states that the left gonad is in front of the intestinal loop, which would make it necessary to place it elsewhere. It cannot be accurately assigned until the structure of its gonads is known.

RHIZOMOLGULA Ritter

Pharynx with six folds on each side. Large infundibula in folds and small accessory ones between folds. Stigmata varying in size, and arranged spirally in the infundibula. Dorsal tubercle with opening between horns directed anteriorly and to left. Dorsal lamina with smooth margin.

Single gonad, situated on the left side, in the intestinal loop. Testicular lobes, bordering and more or less enclosing ovary. Several vasa deferentia, not accompanying oviduct.

Type and single species—**R. globularis* (Pallas) (see Huntsman, 1913, p. 137).

EUGYRA Ald. and Hanc.

Pharynx with from 6 to 9 longitudinal bars on each side in place of folds. Infundibula consisting of one or two spirally coiled stigmata, little or not at all divided. Dorsal lamina with smooth edge. Dorsal tubercle a simple opening, or horse-shoe shaped with opening between horns directed to right or left.

Single gonad, situated on the left side and in or across the inner side of the intestinal loop. Testicular lobes bordering and more or less enclosing ovary. One to several vasa deferentia, not accompanying oviduct.

Type species—*E. arenosa* Ald. and Hanc.

Sub-gen. *Eugyra*

Type—*E. arenosa* Ald. and Hanc.

Infundibula large and in rows corresponding to the longitudinal bars.

In addition to the type, there are *E. adriatica* Drasche, *E. pedunculata* Traust., *E. translucida* Kiaer, and probably *E. bilabiata* Sluiter. We have examined a species from the California coast. *E. kerguelenensis* Herdman probably does not belong in this genus. While Herdman (1882, p. 81) gives the generic characters to include the presence of only a single gonad placed on the left side, he has figured for two specimens of this species (Pl. VI, Figs. 4 and 5) what appears to be a gonad on the right side.

Sub-gen. *Bostrichobranchus* TraustedtSyn. *Herdmania* Metcalfe

Type and single species—*E. pilularis* (Verrill).

Infundibula in adult small, numerous, and irregularly arranged.

CYSTINGIINAE sub-fam. nov.

The stigmata in this sub-family are characteristically variable in length, more or less bent, and arranged rather definitely in a spiral fashion around the infundibula. They do not seem ever to fail to divide and so to form a continuous spiral as in many of the *Eugyrinae*, nor are they subdivided in that regular fashion that produces rows of stigmata transverse to the folds as in the typical *Caesirinae*.

In only two genera (*Paramolgula* and *Pareugyrioides*) do the folds of the pharynx remain in that simple post-larval condition of being represented by single longitudinal bars.

Dorsal tubercle usually well developed, the horns of the slit-like aperture being coiled in the opposite sense, that is, toward each other on the same side (the usual condition in Ascidians). The opening between the horns is directed variously, but usually posteriorly or to the right, that is in directions opposite to the usual ones for the *Eugyrinae*.

In several genera a marked tendency is shown for the intestinal loop to be strongly bent upwards to form a secondary loop.

The left gonad is always above the primary intestinal loop, never in or across it as in the *Eugyrinae*. The testicular lobes are variously arranged, but are never arranged radially in a mass situated at the blind end of the ovary as in the *Caesirinae*.

PARAMOLGULA Traustedt

Syn. *Stomatropa* Pizon

Pharynx with 7 longitudinal bars on each side in place of folds. Infundibula irregular in size and arrangement, each having few to many short stigmata spirally arranged. Dorsal lamina with smooth margin. Dorsal tubercle horseshoe-shaped with horns spirally in-rolled and opening between directed to right side or anteriorly.

Intestinal loop strongly curved into a secondary loop. A gonad on each side, the left above both primary and secondary intestinal loops. Testicular lobes bordering and more or less enclosing ovary on outer side. One to several vasa deferentia attached to mantle parallel to oviduct, and opening near latter.

Type species—*P. schulzii* Traust.

Other species, which, although not fully described, we can with confidence place in this genus, are *P. chilensis* Hartmeyer (1914, p. 18), *P. filholi* (Pizon), *P. gigantea* (Cunningham), *P. glomerata* (Pizon), *P. gregaria* (Lesson), *P. horrida* (Herdman), *P. lebruni*

(Pizon), *P. patagonica* (Michaelson), *P. rugosa* (Pizon) and *P. villosa* (Pizon). Among these there are doubtless several synonyms.

This genus occupies a somewhat isolated position. In the peculiar position of the testicular lobes and vasa deferentia it differs from all other genera of the family except *Ectorchis*. The great number and irregular disposition of the infundibula recall the condition in *Bostrichobrachus* and *Rhizomolgula*. Elsewhere in the *Cystingiinae* the development of small infundibula accessory to the principal ones is not unknown, but is not carried so far as in these three genera.

ANURELLA Lacaze-Duthiers (sens. nov.)

Syn. *Molgula* et *Caesira* auct. (partim.)

Pharynx with seven folds on each side. Infundibula extending into folds, each having many stigmata spirally arranged. Dorsal lamina with smooth margin. Dorsal tubercle with aperture horse-shoe-shaped, the horns incoiled, and the opening between horns directed posteriorly or to right.

A gonad on each side, the left above and parallel to the intestinal loop. Testicular lobes bordering and more or less enclosing ovary. A single vas deferens accompanying ovary and oviduct.

Type species—*A. bleizi* Lac.-Duth.

The only other species that we can assign to this genus is *A. maxima* (Sluiter).

EURITTERIA gen. nov.

Syn. *Molgula* et *Caesira* auct. (partim)

(Named after Prof. W. E. Ritter, who has contributed so much to our knowledge of Ascidians)

Pharynx with 6 folds on each side. Infundibula extending into folds, each having many stigmata spirally arranged. Dorsal lamina with margin smooth or toothed. Dorsal tubercle with slit-like aperture more or less bent into the shape of a horse-shoe, the horns sometimes spirally coiled. Opening between horns directed variously.

Intestinal loop often strongly curved into a secondary loop. A gonad on each side, the left above primary, but in or else closely applied along secondary intestinal loop. Testicular lobes bordering and more or less enclosing ovary. A single vas deferens, accompanying ovary and usually oviduct also.

Type species—**E. cooperi* (Huntsman, 1913, p. 134).

This genus is conveniently divided into three sub-genera.

Sub-gen. *Euritteria* nov.

Dorsal lamina with smooth margin. Opening between horns of dorsal tubercle directed to left. Intestinal loop little or moderately curved. Left gonad rather closely applied to intestinal loop and extending forward out of secondary loop. Right gonad extending forward beyond renal organ.

Type species—*E. cooperi* (Huntsman, 1913, p. 134).

The only other species is *E. regularis* (Ritter).

Sub-gen. *Comita* nov.

(*Comes*, a companion, in allusion to the course of vas deferens).

Dorsal lamina with margin smooth or nearly so. Dorsal tubercle with opening between horns directed variously, usually to left or anteriorly. Intestinal loop somewhat strongly curved into a secondary loop. Left gonad in secondary loop. Right gonad extending around and below anterior end of renal organ.

Type species—*E. arenata* (Stimpson).

Other species are *E. impura* (Heller), and *E. occidentalis* (Traust.).

Sub-gen. *Euperiptycha* nov.

Dorsal lamina more or less toothed on margin. Dorsal tubercle with opening between horns directed posteriorly or to right. Intestinal loop strongly curved into a secondary loop. Left gonad embraced by secondary loop (περιπτύχης, embraced). Right gonad entirely above renal organ.

Type species—*E. socialis* (Alder).

Other species are *E. tubifera* (Orsted), *E. dentifera* (van Beneden), *E. greefi* (Michaelsen), and *E. lütkeniana* (Traust.).

EUGYRIOPSIS Roule

Pharynx with seven folds on each side. Infundibula extending into folds, each having many short stigmata spirally arranged. Dorsal lamina with smooth margin. Dorsal tubercle horseshoe-shaped with incurved horns; opening between horns directed backwards and to left.

A single gonad, situated on the left side above the primary intestinal loop. Testicular lobes bordering and more or less enclosing ovary. Several vasa deferentia, not accompanying oviduct.

Type and single species—*E. intermedia* Roule.

MOLGULA Forbes (sens. restr.)

Pharynx with seven folds on each side. Infundibula extending into folds, each having many rather short stigmata spirally arranged. Dorsal lamina with smooth margin. Dorsal tubercle with aperture in form of slit, usually bent into the shape of a horseshoe with the horns incoiled. Opening between the horns usually directed posteriorly or to the right, but occasionally to the left.

Intestinal loop not strongly curved into a secondary loop. A gonad on each side, the left above primary, and in secondary loop, when such is formed. Testicular lobes bordering and more or less enclosing ovary. One to many vasa deferentia, not accompanying ovary and oviduct.

Type species—*M. oculata* Forbes.

Other species are: *M. pannosa* Verrill, *M. roscovita* (Lac.-Duth.), *M. solenota* (Lac.-Duth.), *M. citrina* Ald. and Hanc., *M. septentrionalis* Traust., *M. apoploa* (Huntsman, 1913, p. 129), *M. hecateia* (Huntsman, 1913, p. 130), *M. pugetiensis* Herdman, *M. pacifica* (Huntsman, 1913, p. 132), *M. birulai* Redikorzew, and *M. helleri* Drasche.

M. arctica Kiaer, *M. psammodes* Traust., *M. siphonalis* Sars, *M. römeri* Hartmeyer, *M. aidae* Oka (1914, p. 453), *M. xenophora* Oka (1914, p. 457) and *M. kophameli* Michaelsen probably belong in this genus as restricted in the diagnosis given, but their descriptions are not sufficiently complete.

GYMNOCYSTIS Giard(sens. nov.)

Syn. *Molgula* et *Caesira* auct. (partim)

Pharynx with six folds on each side. Infundibula extending into folds, each having many rather short stigmata, spirally arranged. Dorsal lamina with margin smooth (or rarely toothed). Dorsal tubercle horseshoe-shaped with horns more or less incurved. Opening between horns directed posteriorly or to right.

Intestinal loop strongly curved into a secondary loop. A gonad on each side, the left above primary, and in secondary intestinal loop. Testicular lobes bordering and more or less enclosing ovary. Several vasa deferentia, not accompanying oviduct.

Type species—*G. ampulloides* P. J. Van Beneden.

Other species are *G. euprocta* (Drasche), *G. manhattensis* (DeKay) and *G. simplex* Hancock.

Molgula georgiana Michaelsen, *M. koreni* Traust., *M. platei* Hartmeyer (1914, p. 8), *M. rotunda* Oka (1914, p. 448) and *Caesira robusta* Van Name (1912, p. 505) perhaps belong here.

This genus has much in common with *Molgula*, but differs rather distinctly from the latter in having the intestinal loop strongly curved into a secondary loop, which embraces the left gonad, as well as in having a smaller number of pharyngeal folds. The latter character is remarkably constant. In these same characters it approaches the sub-genus *Euperiptycha* of the genus *Euritteria*.

CYSTINGIA MacLeay

Syn. *Pera* Stimpson.

Meristocarpus Pizon

Molgula et *Caesira* auct. (partim)

Pharynx with from 5 to 7 folds on each side. Infundibula extending into folds, each having many short stigmata spirally arranged. Dorsal lamina with smooth margin. Dorsal tubercle horseshoe-shaped, with horns sometimes incurved and coiled: opening between horns directed to right or posteriorly.

A gonad on each side, the left ovary above the intestinal loop. Testicular lobes irregularly disposed, with from one to many separate testicular systems, partly beside ovary and partly separate from latter, a portion on the left side frequently in the intestinal loop, and on the right side below the renal organ. Vasa deferentia not accompanying oviduct.

Type species—*C. griffithsii* MacLeay. (*Molgula crystallina* auct., see Huntsman, 1922).

In addition to the type species the genus includes *C. retortiformis* (Verrill), and *C. redikorzevi* Oka, (1914, p. 446).

PAREUGYRIOIDES Hartmeyer

Pharynx with 7 longitudinal bars on each side in place of folds. Infundibula in rows corresponding to the bars, each having rather many spirally arranged stigmata. Occasional accessory infundibula. Dorsal lamina with smooth margin. Dorsal tubercle more or less horseshoe-shaped with opening between horns directed to the right.

A gonad on each side, the left ovary above the intestinal loop. Testicular lobes irregularly disposed with many separate testicular systems in several masses, which are partly beside ovary and partly separated, one mass on the left side being in the intestinal loop. Vasa deferentia not accompanying oviduct.

Type species—*P. dalli* (Ritter, 1913, p. 441).

P. japonica Hartmeyer (1914, p. 23) is a second species.

The condition of the testicular lobes is strikingly like that of *Cystingia*, with which genus it is most closely related. In the primitive condition of the pharyngeal folds it resembles such widely different genera as *Eugyra*, *Paramolgula* and *Gamaster*.

CAESIRINAE sub-fam. nov.

In this sub-family there is a general tendency for the apertural lobes, particularly the oral, to be fringed or subdivided. This reaches its extreme in the unusual forms *Oligotrema* and *Hexacrobylus*, where the lobes are muscular and are possibly used as grasping organs.

The dorsal tubercle, when well developed, has the ends of its slit-like aperture coiled in the same sense, so as to form a reversed S. When the stigmata are well-formed and sub-divided, they are characteristically arranged in rows, which are transverse to the pharyngeal folds and lengthwise of the infundibula. As in the other sub-families, in some genera the pharynx fails to develop beyond a very simple state. This is shown to an extreme degree in *Hexacrobylus*.

An outstanding characteristic of this family is the arrangement of the testicular lobes, which are radially arranged in a more or less compact mass situated at the blind end of the usually elongated ovary.

SYPHONOTETHIS Gervais (sens. nov.)

Syn. *Molgula* et *Caesira* auct. (partim)

Apertural lobes fringed or branched in some species at least, probably in all.

Pharynx with 7 folds on each side. Infundibula usually extending into folds, each having many stigmata which are spirally arranged and usually form rows lengthwise of the infundibula. Dorsal lamina with smooth margin, except near posterior end in some cases. Dorsal tubercle with aperture when well developed, usually reverse S-shaped, the horns turned in and coiled, but in type aperture is horseshoe-shaped, with opening between horns directed to right.

Intestinal loop sometimes strongly curved into a secondary loop. A gonad on each side, the left above primary intestinal loop and more or less in secondary, when latter is well formed. Testicular lobes arranged radially at blind end of ovary. A single vas deferens, accompanying ovary and oviduct.

Type species—*S. tumulus* (Quoy et Gaimard).

Sub-gen. *Syphonotethis*

Type species—*S. tumulus* (Quoy et Gaimard).

Infundibula well formed. Stigmata for the most part in rows. Aperture of dorsal tubercle well developed and characteristically bent.

Vas deferens with straight course along middle of an elongated ovary.

Other species are *S. godeffroyi* (Michaelsen), **S. verrucifera* (Ritter and Forsyth, 1917, p. 446) and *S. conchata* (Sluiter).

Molgula forbesi Herdman and *Astropera sabulosa* Pizon should probably be assigned to this group, but they have not been sufficiently described.

Sub-gen. *Callipera* nov. (κάλλος and πήρα)

Type species—*S. pulchra* (Michaelsen).

Infundibula not well developed, but somewhat flattened. Aperture of dorsal tubercle from simple to crescent-shaped.

Vas deferens with tortuous course over inner surface of a short ovary.

A second species is *S. pyriformis* (Herdman). *Molgula crinita* Sluiter also should probably be placed in this sub-genus.

CAESIRA Fleming

Syn. *Ctenicella* Lacaze-Duthiers (partim)

Molgulidium Seeliger (partim)

Molgula auct. (partim)

Apertural lobes fringed or branched.

Pharynx with seven folds on each side. Infundibula extending into folds, each having many stigmata which are spirally arranged, and at the same time form rows lengthwise of the infundibula. Dorsal lamina more or less toothed. Dorsal tubercle with aperture in the shape of an S reversed, the horns usually turned in and coiled.

Intestinal loop somewhat strongly curved into a secondary loop. A gonad on each side, the left above primary but in secondary intestinal loop. Testicular lobes arranged more or less radially at blind end of ovary. A single short vas deferens, not accompanying oviduct.

Type species—*C. dione* (Savigny).

Other species are *C. appendiculata* (Heller), *C. korotneffi* (Drasche), *C. natalensis* (Michaelson, 1918, p. 2), and *C. cynthiaeformis* (Hartmeyer). From Savigny's account and figures of his species, it is quite clear that it is very close to the species of Heller and Drasche, and, therefore, we may safely infer that it possesses all the generic characters given above, although several minor ones have not yet been demonstrated for it.

Molgula martensi Traustedt may belong here.

LITHONEPHRYA Giard (sens. nov.)

Syn. *Ctenicella* Lacaze-Duthiers (partim)

Molgula et *Caesira* auct. (partim)

Apertural lobes fringed or branched.

Pharynx with 6 or 7 folds on each side. Infundibula extending into folds, each having many stigmata, which are spirally arranged, and at the same time form rows lengthwise of the infundibula. Dorsal lamina more or less toothed. Dorsal tubercle with aperture in the form of a longitudinal slit, the ends of which may turn to opposite sides forming a reversed S.

A gonad on each side, the left above the intestinal loop. In each gonad the oviduct is at the anterior end. Testicular lobes arranged more or less radially at blind (posterior) end of ovary. A single short vas deferens, not accompanying ovary and oviduct.

Type species—**L. complanata* (Ald. and Hanc.).

Other species are **L. tenax* (Traust.), *L. morgatae* (Lac.-Duth.), and **L. canadensis* (Huntsman, 1912, p. 140). *Lithonephrya* exhibits a condition unique for the family, namely a reversal in the orientation of the gonad, the oviduct opening at the anterior or abatrial end of the ovary. In other respects this genus is quite similar to *Caesira*, but with the characteristic features of the latter, such as transverse (to pharynx) arrangement of the stigmata, fringing of apertural lobes, reversed coiling of ends of aperture of dorsal tubercle, and toothed dorsal lamina, less pronounced.

OLIGOTREMA Bourne

Oral aperture with six branched muscular lobes.

Pharynx without proper folds. No infundibula. Stigmata relatively few, short and more or less curved. Dorsal lamina absent. Dorsal tubercle a simple slit.

A gonad on each side, the left above the intestinal loop. Testicular lobes grouped at blind end of ovary, with a single vas deferens, not accompanying ovary and oviduct.

Type and single species—*O. psammites* Bourne.

HEXACROBYLUS Sluiter

Oral aperture with six large branched muscular lobes.

Pharynx without folds. Dorsal lamina with smooth margin. Dorsal tubercle a simple opening. Tentacles simple or absent.

A gonad on each side, the left above the intestinal loop. Testicular lobes grouped at blind end of ovary, with a single vas deferens, not accompanying ovary and oviduct.

Type species—*H. psammatodes* Sluiter.

The only other species of the genus is *H. indicus* Oka (1913, p. 6).

GAMASTER Pizon

Pharynx with seven longitudinal bars on each side in place of folds. Infundibula in rows corresponding to the bars, each consisting of one or two long spirally coiled stigmata. Condition of dorsal lamina and dorsal tubercle not known.

A single gonad, situated on the right side. Testicular lobes arranged radially at blind end of ovary. Vas deferens (or vasa deferentia?) not accompanying ovary and oviduct.

Type species—*G. dakarensis* (Pizon).

The only other species is *G. woermanni* (Michaelson), described by Michaelson in 1914 (p. 423) as *Eugyra w.* Its affinities are, however, definitely with Pizon's species. *Gamaster* parallels the typical *Eugyrinae* both in the condition of the stigmata and in the failure of the pharyngeal folds to develop.

Uncertain Genera

Hartmeyer (1914, p. 8) has formed the genus *Molgulina* for those species, formerly assigned to the genus *Molgula* or *Caesira*, which have a small number of longitudinal bars on each fold and the infundi-

bula flattened out. This group, as well as the genus *Molgula*, as the latter would then be, seems quite heterogeneous and unnatural. The type, *M. eugyroides* (Traust.) possesses very curious gonads, and on this basis the genus doubtless will be a valid one, but the structure of these gonads has not yet been sufficiently described.

Similarly it has been impossible to consider *Ascopera* Herdman, and *Bathypera* Michaelsen in the classification here proposed, owing to their structure being so imperfectly known.

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